

# NASA TECH BRIEF



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## Computer Program Provides Improved Longitudinal Response Analysis for Axisymmetric Launch Vehicles

### The problem:

To develop an improved linear analytical model and digital program for the calculation of axisymmetric launch vehicle steady-state response to axisymmetric sinusoidal loads. In the evaluation of launch vehicle behavior, it is necessary to study the response of the entire vehicle to this type of dynamic loading to insure the structural integrity and stability of the system.

### The solution:

A finite element technique is utilized to construct the total launch vehicle stiffness matrix and mass matrix by subdividing the prototype structure into a set of (1) axisymmetric shell components, (2) fluid components, and (3) spring-mass components. In this way, it is possible to represent as separate shell units the fairing, interstage structure, bulkheads, tank walls, and engine thrust structure, and to conveniently provide for the inertial and stiffness characteristics of equipment, engines, and vehicle supporting structure.

### How it's done:

The stiffness and mass matrices for the complete launch vehicle are obtained by superposition of the stiffness and mass matrices of the individual shell, fluid, and spring-mass components which are computed using a Rayleigh-Ritz approach. Fluid motions are assumed to be consistent with the shell component distortions. After the complete system stiffness and mass matrices have been formulated, displacement boundary conditions are introduced by removing appropriate rows and columns corresponding to coordinates of the vehicle and its supports which are restrained from motion.

The system natural frequencies and mode shapes are obtained from an eigenvalue equation constructed with the total stiffness and mass matrices. The steady-state response due to simple harmonic loads is determined using a standard modal response procedure which expresses the total displacement, velocity, acceleration, and force responses as the linear superposition of the individual modal responses based on an assumed modal damping. The procedure will handle shell components with a number of axisymmetric geometries. The approach has the capability of representing the tank or stage of most interest in great detail and those of least interest with minimum detail. The formulation of the problem is subdivided into well-defined portions, facilitating modification of coding for more detailed treatment of system behavior.

### Notes:

1. This program is written in Fortran IV for an IBM 7094 computer.
2. The detailed computer programming manual for the digital program is available.
3. Inquiries concerning this program may be directed to:

COSMIC  
Computer Center  
University of Georgia  
Athens, Georgia 30601  
Reference: B67-10531

### Patent status:

No patent action is contemplated by NASA.

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